Visualization, Distribution and Delivery of 3D Parcels
Position Paper 4

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1. INTRODUCTION

This paper is the second of two position papers that serve as the basis for discussion in a forum held at the 4th International on 3D Cadastres, 9-11 November 2014, Dubai, UAE. The first paper was published in 2011 (Pouliot, 2011). The overall objective of the FIG Working Group discussion is to provide feedback to the FIG Commission 3 (Spatial Information Management) and FIG Commission 7 (Cadastre and Land Management) and EuroSDR. Four working sessions are planned; this paper applies to working session #4.

1. Legal framework for 3D Cadastres;
2. Initial registration of 3D parcels;
3. 3D data management;
4. Visualization, distribution and delivery of 3D parcels.

Discussions will be held on questions like: what problem is to be addressed; what are the potential solutions; what progress has been made since the 2nd International Workshop on 3D Cadastres (in 2011); what are the recommendations.

We can summarize the 2011 discussions about visualization, distribution and delivery of 3D parcels like this (Pouliot, 2011; Banut, 2011):

- The categories of users and users' requirements must be taken into consideration.
- Viewing the physical objects is easy (many 3D models available) but viewing the legal objects is much more relevant and challenging since these objects are by nature invisible and based on human decision (more open to debate).
- Having 3D representation (volumetrics) of 3D parcels (compared to 2D or 2.5D representation) is not an obligation. It is better to have access to spatial representation customized (to user needs).
- Measuring in 3D is not trivial; access to new tools to help select and snap objects would be better. Designers often fail to achieve a balance between design and function, creating gorgeous data visualizations which fail to serve their main purpose — to communicate information.
- Web mapping is a good solution to integrate various sources of data; it is important to have standards for storing and querying 3D data (strong relation with displaying).
- Increased development of open source solutions and 3D viewers like Adobe (accessible, reach large public) is needed.
- There is an interest in using crowdsourcing for mapping.

The paper is organized as following: Section 2: Brief presentation of the state of the art; Section 3: Key topics and possible solutions; and Section 4: Conclusion. Note that we will not repeat the contents of the paper published in 2011 (Pouliot, 2011), only covering recent developments (since 2011). In this discussion, 3D parcels will refer to 3D spatial units to

which right, restriction, responsibility (RRR) are attached, where the ownership spaces (or parcels) should not overlap other ownership parcels (Van Oosterom et al, 2013). It is also worth mentioning that the exact definition differs under different legal and organizational situations.

2. STATE OF THE ART

Based on more than 100 papers found in the literature on 3D cadastre since 2011, fewer than 10 publications have their main focus on the visualization, distribution and delivery of 3D parcels.

For instance, a number of countries, like Australia (Karki et al, 2011; Shojaei,et al, 2012), China (Guo et al, 2013), Indonesia (Aditya et al, 2011), Korea (Jeong, et al, 2011), and Russia (Vandysheva et al, 2011; 2012), have implemented prototypes for the visualization of 3D cadastre systems. Advances in 3D GIS (geographic information system) like CityEngine or CAD (computer aided design) software like BIM or 3D printing, as well as the success of WebGL and HTML5, provide additional technical possibilities for 3D parcel visualization. For instance, browser-based, on-line visualization was a topic of intense interest, mainly because it improves access for the general public. In the prototype construction, several shortcomings of current platforms have been identified by Shojaei et al (2014). For example, the visualization of underground 3D parcels is not well supported by Google Earth. There is also a dearth of research regarding stereoscopic and immersive virtual reality for visualizing 3D parcels. Guo and others (Guo et al, 2013; Ying et al, 2012) propose the use of multi-viewpoint 2D representation to enable the visualization of 3D parcels when no 3D visualization device is available or when the legal and organizational requirements stipulate a paper-based document.

A Canadian team (Pouliot et al, 2014a and Wang et al, 2012), proposed analyzing the performance of visual variables and revisiting cartographic foundations to respond to the requirements of 3D visualization of legal units. Their conclusions pointed out about the identification of cartographic and modeling principles customized for the 3D visualization of legal property and to respond to notarial task purposes. Until now, they were not fully able to identify distinctive advantages of visual variables for cadastral purposes compared to classic 3D viewing. More recently, they explored the performance of transparency to provide legal and physical boundary distinctions (Pouliot et al, 2014b). Shojaei et al (2013) worked with the same hypothesis to obtain the distinctive visualization cadastral features. The proposed cadastral features did not totally emphasize the singularity of 3D cadastral visualization. Visualizing underground (legal) objects like communication networks, gas pipelines, or mining properties may also be examined from the same research standpoint. Guo (2012), Jeong (2012), Shojaei et al (2013) and Vandysheva et al (2012) proposed the visualization of this specific category of legal object as part of whole 3D models. Apart from Pouliot et al (2015), who suggest specific visualization schema for underground legal objects, no specific recommendation have been proposed although all authors indicate that this category of legal object encompasses its own challenges: being not visible, having singular geometry crossing other multiple legal objects (like parcels) and requiring topological analysis.

Integrating user requirements in the design of 3D visualization frameworks was addressed by some researchers, like Shojaei, et al (2013 and 2014), Pouliot et al (2014), Vandysheva et al (2012). End-users targeted were managers in government and municipal authorities responsible for the maintenance of the land administration system, lawyers and notaries, land surveyors, architects, corporate owners (building managers). No matter the results, the key outcome of this approach was to help promote usage of the 3D cadastre model in professional activities.

Three-dimensional visualization of 3D parcels was also investigated in correlation with the conceptual data modeling and data structure (Aien et al, 2013; Fredericque et al, 2011). As well, several researchers examined the distribution and delivery of 3D parcel data as a part of 3D SDI (Spatial Data Infrastructure) in order to work together with other 3D spatial data for multiple land-related purposes like urban planning (Abdul-Rahman et al, 2012; Stoter et al, 2011; Riecken & Seifert, 2012). Standards that integrate the third dimension of the data are certainly one of the foundations of data distribution and delivery. These standards include ontology standards, data service standards, and data format standards. LADM (Land Administration Data Model), accepted as the ISO standard, is definitely the main one to consider (ISO-TC, 2011, Jeong, et al, 2012; Pouliot & Vasseur, 2011). Researchers also tested CityGML as a semantically rich data format (van den Brink et al, 2013) and X3D, a visualization-centric data format (Aditya et al, 2011). OGC's web 3D service has also been used as a 3D cadastre prototype (Vandysheva et al, 2011). Instead of researching how to distribute and deliver 3D parcel data, researchers have investigated how 3D parcel data may play a role to support land-related tasks and decision making when combined with other sources of data.

3. KEY TOPICS and POSSIBLE SOLUTIONS

As stated in 2011, by Banut in the report on the 2nd Cadastres workshop, technical aspects of 3D parcel visualization are still challenging but they are not foreseen to be the main obstacles. Even though important progress has been made, as previously stated, the penetration of 3D models (and their visualization) in the day-to-day activities of professionals requiring cadastral data is still limited. We may ask why. In 2011, we suggested a long list of key topics. From our point of view, some concerns are still of prime importance:

- Should we require 3D models for the visualization of 3D parcels and related RRR? Is 2.5D representation, or 2D parcel plans with attribute data referring to relevant information of overlapping objects (or easement projections) enough to support the decision making process?
- Who is interested in 3D Visualization, and the distribution and delivery of 3D parcel data? Do we adequately understand their interests, terminology, procedures, and requirements? Land law specialists and land transaction professionals need to be involved in research and development activities. Should we be more concerned about training a new generation of cadastre data users, who are more aware of the capacities of 3D visualization? Should we place more effort on promoting technology transfer of research prototypes?
- What about the user interface? The immersive environment?

- Should knowledge taken from visualization science, information visualization and human-computer interaction be more intensively embedded in the 3D cadastre research program?
- Does the 3D medium perform better in the visualization of legal objects crossing other multiple legal objects (or parcel) or unbounded legal object?
- Is 3D visualization investigation to be undertaken in correlation with multipurpose 3D cadastre and multi-users database design in which the integration of auxiliary documents, like title or deed, would be mandatory? What should be the visualization schema for multipurpose cadastre?
- 3D City Models, 3D Building Models and 3D Cadastre Models, what are the differences (from a visualization point of view)?
- 4D cadastre, or the integration of time (or history), has been investigated by some researchers (Döner et al, 2011; Siejka et al, 2013). This opens interesting questions regarding the visualization of such information (e.g. slider, graph). Is additional investigation required?
- Will new data acquisition techniques like LiDAR, Georadar, or even crowdsourcing data pushing impact the data visualization and distribution schema?

Finally, we may also sketch a quick overview of trends in 3D Geovisualisation or computer vision, unrelated to cadastral application. These insights may provide interesting suggestions for ways forward in the visualization, distribution and delivery of 3D parcels.

- New rendering techniques for thematic color mapping;
- Photo realistic visualization (like texture mosaic) and non-photo realistic visualization;
- Immersive and interactive 3D visual display;
- Multimedia, augmented reality and mobile technology;
- Schematized maps; or how to maximize task-adequacy while minimizing non-functional detail;
- Generalization of higher dimensional data (3D and temporal data) like automated, on-the-fly, and contextual generalization;
- Capturing of user requirements for on-demand mapping and dealing with different communities of users;
- GeoBIM data (combining above ground and subsurface application);
- Ringmap to display a time series.

4. CONCLUSION

Have we made any progress since 2011 regarding visualization, distribution and delivery of 3D parcels? In four years, we found less than 10 targeted publications among 100 papers on 3D cadastre. Progress on the relevant topics will certainly be advanced if the number of publications grows (and in scientific journals). The coming 3D Cadastres workshop will be an excellent occasion for sharing experiences, improving collaboration, and jointly providing a tentative answer to the essential question of quantifying progress. I invite attendees to the coming workshop to prepare a checklist of the pros and cons of the previously identified key topics.

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BIOGRAPHICAL NOTES

Jacynthe Pouliot is a full professor at the Department of Geomatics Sciences (www.scg.ulaval.ca) at Université Laval, Quebec, Canada and currently the head of the Unit. She is an active researcher at the Center for research in Geomatics (www.crg.ulaval.ca) and received a personal discovery grant from the Natural Sciences and Engineering Research Council of Canada. Her main interests are the development of GIS systems, the application of 3D modeling techniques, and the integration of spatial information and technologies. She has been a member of the Professional association of the Quebec land surveyors since 1988. She is also involved in the supervising committee of the 3D Ethics Charter (www.3dok.org) and a member of the FIG working group on 3D Cadastres.

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